SPECTROSCOPY AMPLIFIER
Model 2011

Instruction Manual

Canberra Industries, Inc., One State Street, Meriden, CT 06450 Tel. (203) 238-2351 TWX: 710-461-0192 Cable: CANBERRA

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SPECTROSCOPY AMPLIFIER
MODEL 2011

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Section 1
INTRODUCTION

1.1 GENERAL DESCRIPTION

The Canberra Model 2011 Spectroscopy Amplifier offers a unique combination of switch selectable pulse shaping time constants and output characteristics in a single width NIM module. The Model 2011 possesses the latest advance in spectroscopy amplifier technology utilizing the same state-of-the-art integrated circuits and design as our high performance spectroscopy amplifiers. The Model 2011's gain range (X3 to X3000) makes it compatible with a broad range of scintillation photomultipliers, gas proportional, silicon surface barrier and Ge(Li) detectors. The amplifier's restorer includes circuitry for sensing the reset signals present with optical coupled feedback preamplifiers used in intrinsic germanium application.

Canberra's semi-Gaussian pulse shaping is an optimum compromise between the conflicting requirements of maximizing signal-to-noise ratio and minimizing the sensitivity of output amplitude to variations in detector rise time. The active filter shaping forces a monotonic return to baseline to prevent secondary under and overshoots. The amplifier's ultra-low noise contribution and clean return to baseline results in unexcelled resolution. The versatility of the Model 2011 is enhanced by its choice of shaping time constants (.5, 1.5, 3.0 and 4.0μsec) which are front panel switch selectable. Unipolar shaping is achieved with one differentiator and two active filter integrators. The differentiator is placed early in the amplifier to insure good overload recovery. The integrators are placed late to minimize noise contribution from the gain stages.

The gated active baseline restorer for the Unipolar Signal offers superior high count rate performance. Canberra's gated DC restoration technique virtually eliminates three undesirable characteristics inherent in most commercially available DC restorers: (1) baseline undershoots following the linear signal, (2) correlated noise, (3) non-linear response at low amplitude signals.

Simultaneous unipolar and bipolar outputs are available at both front and rear panel BNC connectors. The unipolar signal is DC restored and either prompt or delayed by 2μsec.

The low spectrum broadening and excellent count rate stability achieved by this amplifier makes the 2011 an ideal instrument to insure superior performance of most modern detectors.

1.2 APPLICATIONS

This section is not intended to serve as a complete list of applications. It is intended to identify some of the important features, and to indicate areas where they might be applied.

1.2.1 GENERAL

The 2011 Spectroscopy Amplifier with its selection of shaping time constants allows it to be used in surface barrier, proportional counter, NaI and Ge(Li) detector Applications. By having only one baseline restoration rate, which adequately covers a broad count rate range, the amplifier is easily set up and used in any of the above counting applications.

This amplifier is ideally suited for use with various geometries and size of NaL and Ge(Li) detectors for counting gamma events and selecting coincidence occurrences. With a silicon surface barrier detector, the selection of 0.5μsec shaping time constant makes the 2011 suitable for high resolution work. The excellent stability and low noise contribution enhances the use of this amplifier in any of these applications.

1.2.2 POSITION SENSITIVE DETECTOR SYSTEM

Two 2011 Spectroscopy Amplifiers are utilized in the position sensitive detector system of figure 1-1; one is used in each leg of the system. As a beam strikes the position sensitive detector a signal originates from each side; the time difference between these pulses is dependent on the position of the beam. The 2011 is of key value in this system by virtue of its selectable shaping time constants and simultaneous bipolar and unipolar output pulses. Either type output may be fed into dual high quality Timing SCA's (constant fraction type for unipolar, or crossover type for bipolar pulse) to generate precise timing reference output signals. These output signals are used as the start and stop gates of a Time-to-Amplitude Converter (TAC). The TAC generates an output analog pulse whose amplitude is proportional to the time difference between the detector signals and, therefore, the position of the deflected beam.

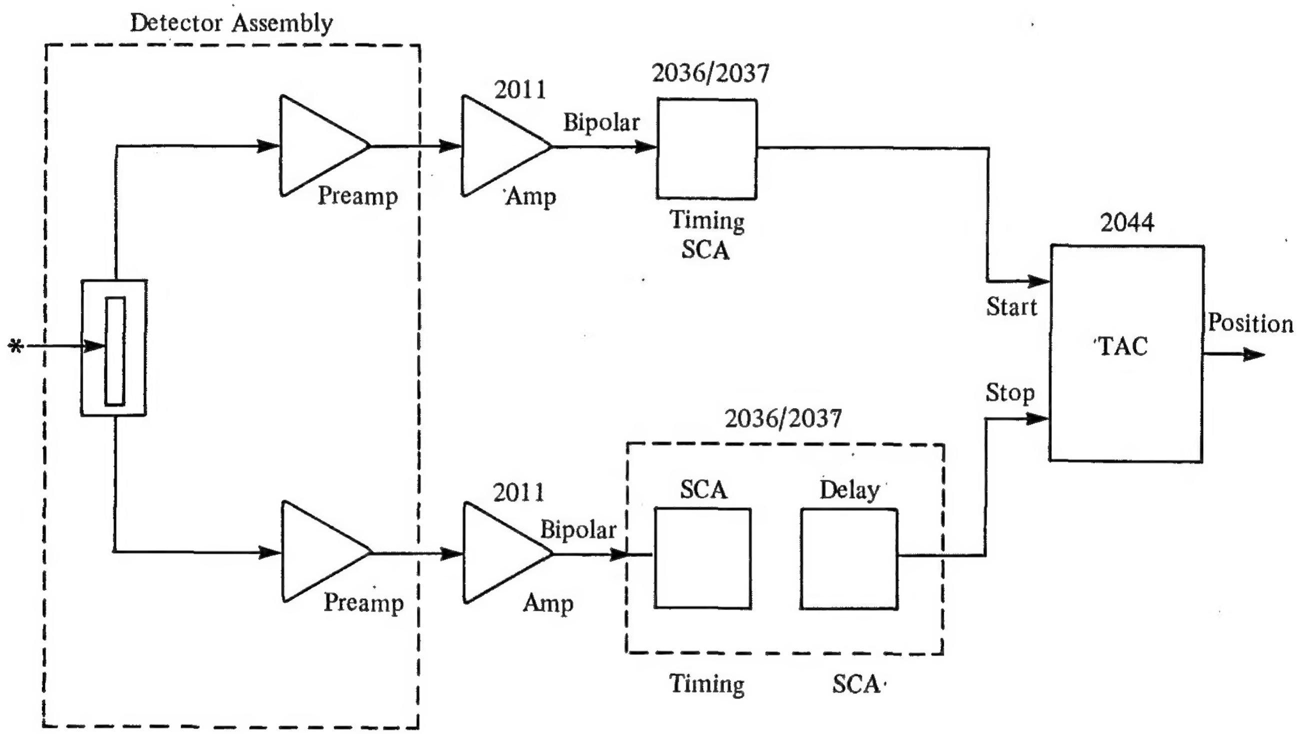


Figure 1-1: Position Sensitive Detector System

Section 2
SPECIFICATIONS

2.1 INPUTS

(SIGNAL) INPUT	Accepts positive or negative Linear pulses from an associated preamplifier. Input BNC connectors located on front and rear panel Amplitude: 0 to ± 12 volts max, 0 to ± 3.2V for a Linear output. Rise Time: less than shaping time constant selected. Decay Time Constant: 30μsec to ∞ Input Impedance: Approximately 1K ohms.

2.2 OUTPUTS

UNIPOLAR OUTPUT	Provides positive Linear pulses. BNC connectors are located on the front and rear panels. Short circuit protected. Amplitude: +10 volts, +12 volts maximum. Timing: prompt or 2μsec delayed, internally selected. Shaping: Active filter near-Gaussian shaped. Coupling: DC restored. DC level: Internally adjustable between ± 100mV, factory adjusted for ± 1mVDC. Front Panel Z_{out}: less than 1 ohm or 93 ohms, internally selectable. Rear Panel Z_{out}: 93 ohms.
BIPOLAR OUTPUT	Provides positive lobe leading Linear shaped pulses. BNC connectors located on front and rear panels, short circuit protected. Amplitude: +10 volts, +12 volts maximum. Timing: prompt, positive Lobe Leading. Shaping: Active filter near Gaussian shaped. Coupling: DC DC level: less than ± 20mV Front Panel Z_{out}: less than 1 ohm or 93 ohms, internally selectable. Rear Panel Z_{out} 93 ohms. The Bipolar Output has no specific timing relationship to the Unipolar Output.

2.3 PERFORMANCE

GAIN RANGE	Continuously adjustable from X3 to X3000, product of Coarse and Fine Gain Controls. Coarse Gain steps are: X10, X30, X100, X300, X1K and X3K. Fine Gain covers a range of X.3 to X1
OPERATING TEMPERATURE RANGE	0 to +50^{o}C

GAIN DRIFT	less than ± 0.0075%/°C of full scale
DC LEVEL DRIFT	less than ± 50μV/° C
INTEGRAL NONLINEARITY	less than ± 0.05% of full scale linear output range.
OVERLOAD RECOVERY	Unipolar (Bipolar) recovery to within 2% (1%) of full scale output from X1000 overload in 2.5 (2.0) non-overloaded pulse widths, at full gain, for any shaping time constant, and pole-zero cancellation properly set.
PULSE SHAPING	Near-Gaussian shape: one differentiator, two active integrators, and only one secondary time constant (approximately 50 milliseconds); time to peak is approximately 1.75 times the shaping time constant.
SHAPING TIME CONSTANTS	Front panel pushbutton switches; both switches Out: 0.5μsec shaping, with an ADD 1μsec pushbutton switch and an ADD 2.5μsec pushbutton switch. Any combination may be used; 0.5μsec, 1.5μsec, 3μsec or 4μsec.
NOISE CONTRIBUTION	Unipolar Output: 3 microseconds shaping time constant, less than 3.5 microvolts referred to input, any amplifier gain more than 100. Bipolar Output: 3 microseconds shaping time constant, less than 5.5 microvolts referred to input, any amplifier gain more than 200.
RESTORER	Time variant (gated); ON continuously.
COUNT RATE PERFORMANCE	Unipolar (Prompt) Output, 1.5μsec shaping.
SPECTRUM BROADENING	FWHM of a CO^{60}, 1.33MeV gamma peak for an incoming count rate of 2K cps to 70K cps and a 9 volt pulse height will typically change less than 18%.
PEAK SHIFT	The peak position of a CO^{60}, 1.33MeV gamma peak for an incoming count rate of 2K cps to 70K cps and a 9 volt pulse height will shift less than 0.035%.

POWER SUPPLY SENSITIVITY

SUPPLY	AMP DC LEVEL
+24V	10mV/V
- 24V	20mV/V
+12V	5.6mV/V
- 12V	5.6mV/V

SUPPLY	AMP GAIN
+24V	0%/V
- 24V	0.09%/V
+12V	0.05%/V
- 12V	0.05%/V

CROSSOVER WALK	Bipolar Output walks less than ± 3 nanoseconds for a 50:1 dynamic range.

2.4 JUMPER PLUGS

UNIPOLAR Z_{OUT}	Internal 2 position jumper plug that sets the output impedance of the front panel UNIPOLAR OUTPUT to either less than 1 ohm or 93 ohms. The 2011 is shipped with the jumper plug in the less than 1 ohm position.
BIPOLAR Z_{OUT}	Internal 2 position jumper plug that sets the output impedance of the front panel Bipolar Output to less than 1 ohm or 93 ohms. The 2011 is shipped with the jumper plug in the less than 1 ohm position.
DELAY	There are 2 internal jumper plugs that set the Unipolar Output to be PROMPT or 2μsec DELAYED. The 2011 is shipped with the jumper plugs in the PROMPT position.

2.5 CONNECTOR TYPES

SIGNAL INPUT	Front and rear panel, BNC.
UNIPOLAR OUTPUT	Front and rear panel, BNC.
BIPOLAR OUTPUT	Front and rear panel, BNC.
PREAMPLIFIER PULSER	Rear panel, Amphenol #17-10090
TEST POINTS	Unipolar, Bipolar Outputs, Front panel, Selectro-SKT-41.

2.6 POWER REQUIREMENTS

+24VDC	–	75mA
- 24VDC	–	80mA
+12VDC	–	35mA
- 12VDC	–	45mA

2.7 PHYSICAL

SIZE	Standard Single-width NIM module 1.35 x 8.71 inches (3.43 x 22.13 CM) per TID 20893 (rev.).
NET WEIGHT	2.3 lbs. (1.05 kgs.)
SHIPPING WEIGHT	4.0 lbs. (1.8 kgs.)

Section 3
CONTROLS AND CONNECTORS

3.1 GENERAL

Complete understanding of the purpose of the various controls and connectors is essential for the proper operation of the Model 2011, and it is recommended that this section be read before proceeding with the operation of the module.

3.2 FRONT PANEL
(see Figure 3-1)

COARSE GAIN
Six position rotary switch selects gain factors of X10, X30, X100, X300, X1K and X3K; multiplied by the FINE GAIN control settings.

POLE ZERO
22 turn screw driver adjust potentiometer to compensate for the undershoot caused by the preamplifier fall time constant. Adjustable for preamplifier fall time range of 30μseconds to ∞

INPUT
Accepts positive or negative linear pulses from associated preamplifier. Signal requirements are: Amplitude 0 to ±12 volts max.; Rise time less than the shaping time constant; Decay time constant 30μseconds to ∞ Z_{in} approximately 1K ohms.

FINE GAIN
Ten turn precision potentiometer selects variable gain factors from X.3 to X1. Resetability within ±0.03%.

INPUT POLARITY
Toggle switch to set the 2011 for the polarity of the incoming preamplifier signal.

SHAPING
Two pushbutton switches selects active filter (semi-gaussian shaped) time constant of 0.5, 1.5, 3 or 4μsec.

UNIPOLAR OUTPUT
Provides a positive unipolar semi-gaussian pulse. Look under section 2.2 for signal specifications.

BIPOLAR OUTPUT
Provides a prompt double differentiated linear output pulse. Look under Section 2.2 for signal specifications.

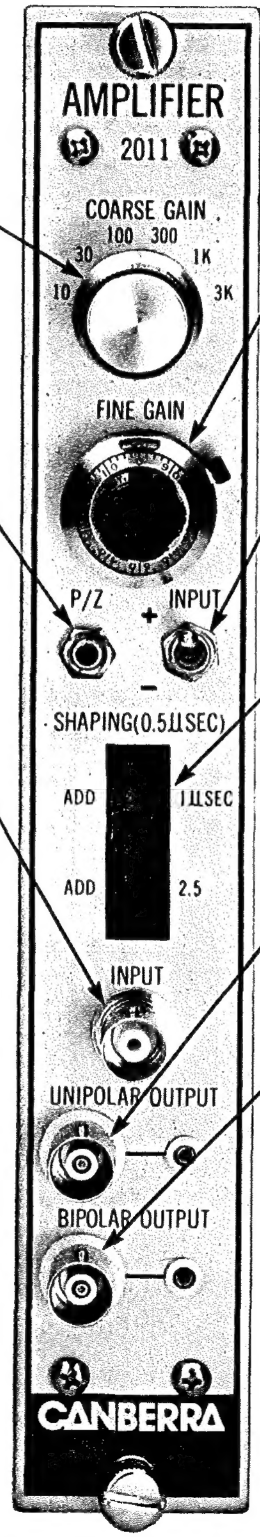


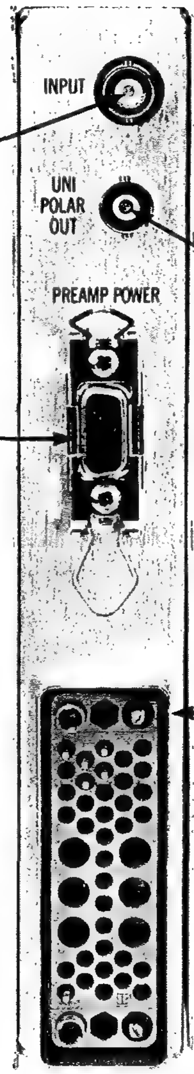
Figure 3-1. Front Panel Controls and Connectors.

3.3 REAR PANEL (See Figure 3-2)

INPUT
Additional input wired in parallel with the front panel signal INPUT BNC connector.

PREAMP POWER
Provides power for any Canberra preamplifier; Model 1708 preamplifier requires a special cable.

PIN	FUNCTION
1	Ground
2	Clean Ground
4	+12VDC
6	- 24VDC
7	+24VDC
9	- 12VDC



UNIPOLAR OUTPUT
Signal specifications are identical to the front panel output except for 93 ohm series - connected output impedance. Use this rear panel output when driving long lengths of interconnecting coaxial cable to prevent distorting the linear signal (oscillations).

MODULE POWER
Connector accepts operating voltages from an AEC Standard NIM bin/power supply such as the Canberra Model 2000.

PIN	FUNCTION
16	+12VDC
17	- 12VDC
28	+24VDC
29	- 24VDC
34	Ground
42	Clean Ground

Figure 3-2. Rear Panel Controls and Connectors.

Section 4
OPERATING INSTRUCTIONS

4.1 GENERAL

The purpose of this section is to familiarize the user with the operation of the Model 2011 Spectroscopy Amplifier and to check that the unit is functioning correctly. Since it is difficult to determine the exact system configuration in which the module will be used, explicit operating instructions cannot be given. However, if the following procedures are carried out, the user will gain sufficient familiarity with this instrument to permit its proper use in the system at hand.

4.2 SPECTROSCOPY SYSTEM OPERATION

The following instructions apply to obtaining the maximum performance capabilities of the Model 2011 depending on operating and system needs.

4.2.1 SYSTEM SETUP

A block diagram of a typical Canberra gamma spectroscopy system is shown in Figure 4-1.

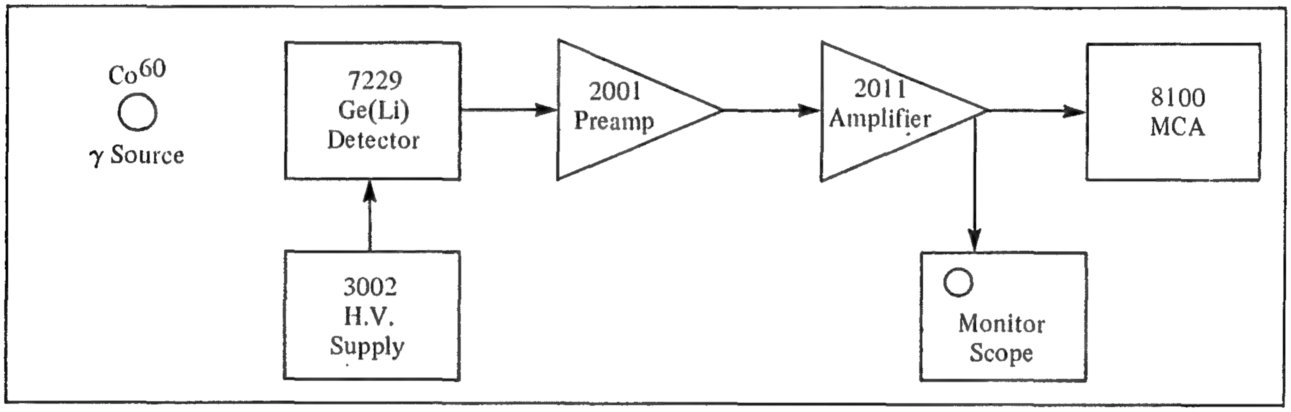


Figure 4-1. Typical Gamma Spectroscopy System.

1. INTERNAL JUMPER PLUGS

   Prior to installation and set up the internal jumper plugs should be set to their desired positions. See Figure 3-3.

   There are 2 internal jumper plugs (J6 and J7) that set the UNIPOLAR OUTPUT to be PROMPT or 2μsec DELAYED. The 2011 is shipped with the jumper plugs in the PROMPT position.

   There are 2 more internal jumper plugs which control the output impedance of the front panel (only) UNIPOLAR and BIPOLAR OUTPUTS. The output impedances can be changed from less than 1 ohm to 93 ohms. The 2011 is shipped with the output impedances set for less than 1 ohm. The Rear panel outputs have a fixed output impedance of 93 ohms series-connected.

   When using the front panel low impedance outputs, short lengths of interconnecting coaxial cable need not be terminated. To prevent possible oscillations, longer cable lengths should be terminated at the receiving end in a resistive load equal to the cable impedance (93 ohms for type RG-62/U cable).

The 93 ohm outputs may be safely used with RG-62/U cable up to a few hundred feet. However, the 93 ohm impedance is in series with the load impedance, and a decrease in the total signal range may occur. For example, a 50% loss will result if the load impedance is 93 ohms.

2. Insert the 2011 into a standard Nuclear NIM BIN. Preamp power is provided by means of a connector located on the rear panel of the 2011 amplifier. Allow the total system to warm up and stabilize.

3. Set the 2011 controls as indicated below:

   a. Shaping: 3μsec.
      Coarse Gain: 100
      Fine Gain: 7.5

   This will give approximately a 9 volt output when using a preamp gain of 100mV/MeV and a Co^{60} radioactive source.

   b. Set the INPUT POLARITY switch to match the output polarity of the preamp.

4. Install a "Tee" connector on the 2011 Unipolar Output. Connect one end to the ADC Input on the analyzer. The ADC must be direct coupled for linear input signals to fully exploit the count rate capabilities of the Model 2011 Amplifier. All Canberra ADC's are DC coupled.

   Connect the 2nd end of the "Tee" connector to an oscilloscope to monitor the UNIPOLAR OUTPUT.

4.2.2 PERFORMANCE ADJUSTMENTS

a. The Pole/Zero is extremely critical for good high count rate resolution. See note 1 on page 4-5. Adjust the radiation source count rate between 2 kcps and 25 kcps. While observing the UNIPOLAR OUTPUT on the scope, adjust the Pole/Zero so that the trailing edge of the gaussian pulse returns to the baseline with no over or undershoots. Figure 4-2a. shows the correct setting of the Pole/Zero control, with Figures 4-2b. and 4-2c. showing under and over compensation for the preamplifier decay time constant. Notice some small amplitude signals with long decay times in Figure 4-2a. These are due to charge trapping in the detector and cannot be corrected by the Pole/Zero control.

b. Pole Zero adjustment using a square wave and preamp test input. See Note 2 on page 4-5.

   Driving the preamp test input with a square wave, will allow a more precise adjustment of the amplifier P/Z.

   1. The Amplifier's controls should be basically set for its intended application; coarse gain, shaping, input polarity.

   2. Adjust the square wave generator for a frequency of approximately 1kHz.

   3. Connect the Function Generator's output to the Preamp's Test Input.

   4. Remove all radioactive sources from and near the detector.

   5. Set the scope's Chan. 1 vertical sensitivity to 5 Volts/Div., and adjust the main time base to 0.2msec/Div. Monitor the 2011's UNIPOLAR OUTPUT and adjust the function Generator's amplitude control (attenuator) for output signals of ± 8 volts.

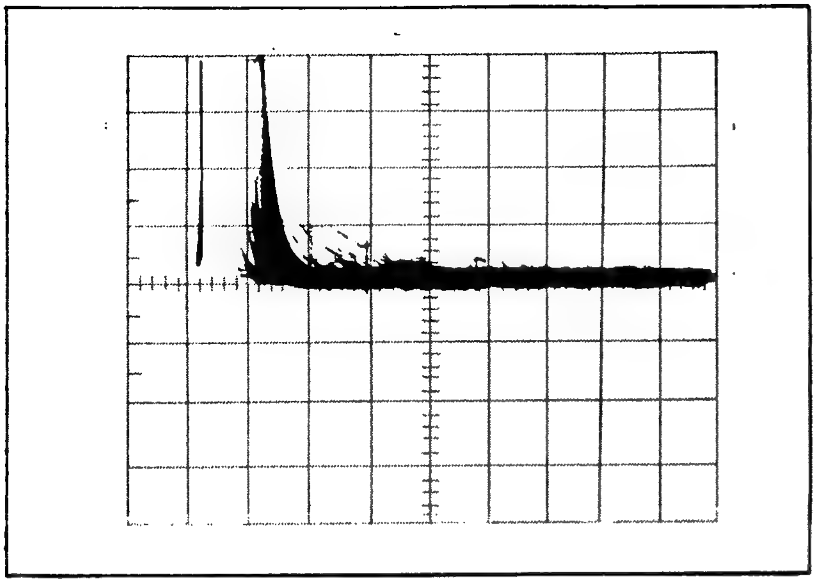


Figure 4-2a.
Correct P/Z Compensation

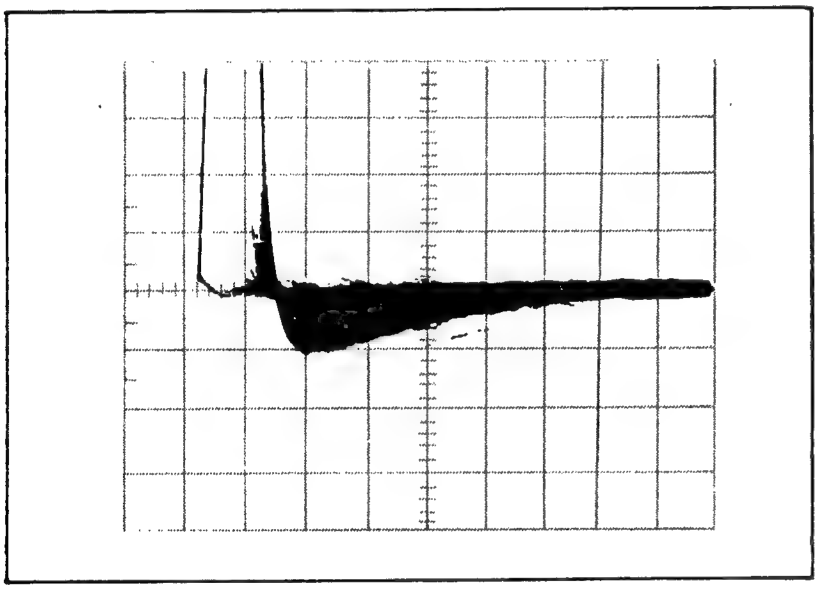


Figure 4-2b.
Undercompensated P/Z

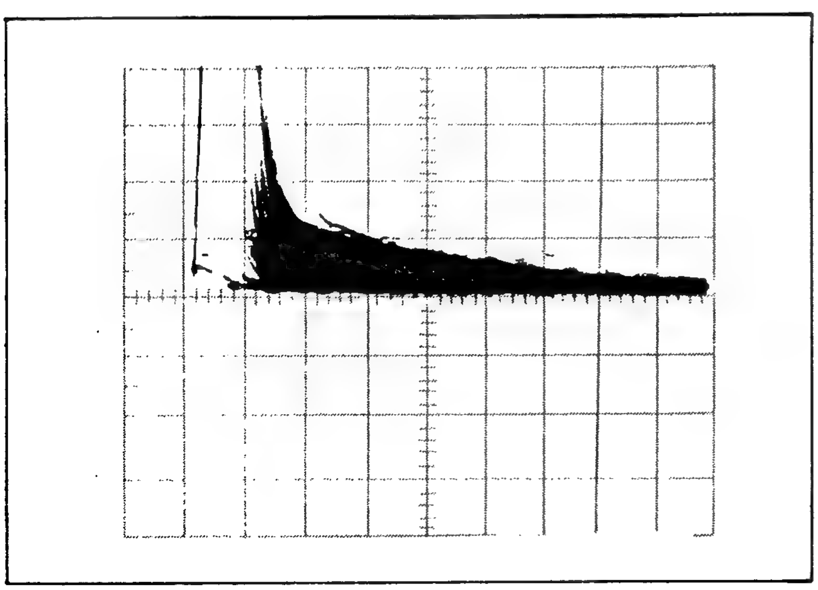


Figure 4-2c.
Overcompensated P/Z

Oscilloscope
Vert: 50mV/Div
Horz: 10μsec/Div

Source Co^{60}
1.33MeV Peak: 7V Amplitude
Count Rate: $\approx$ 3kcps
Shaping: 3μsec.

Figure 4-2. Pole/Zero adjustment with a Live source (Co^{60})

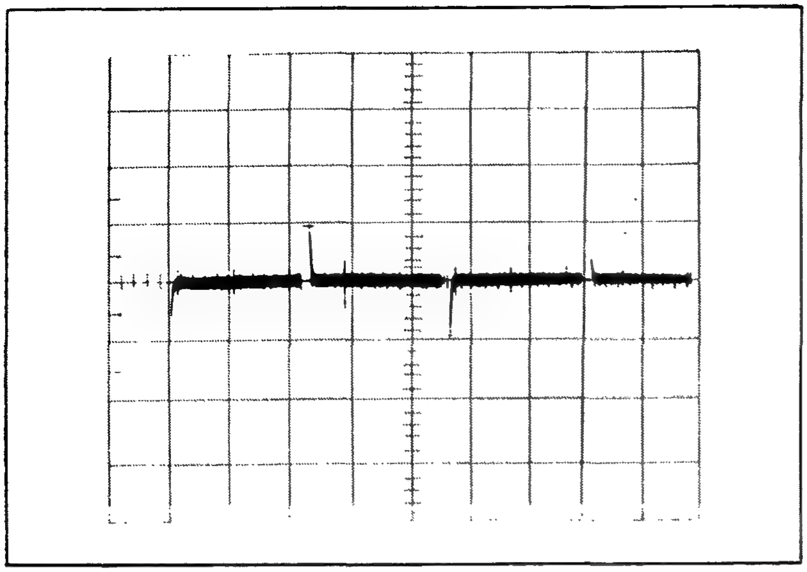


Figure 4-3a.
Correct P/Z Compensation

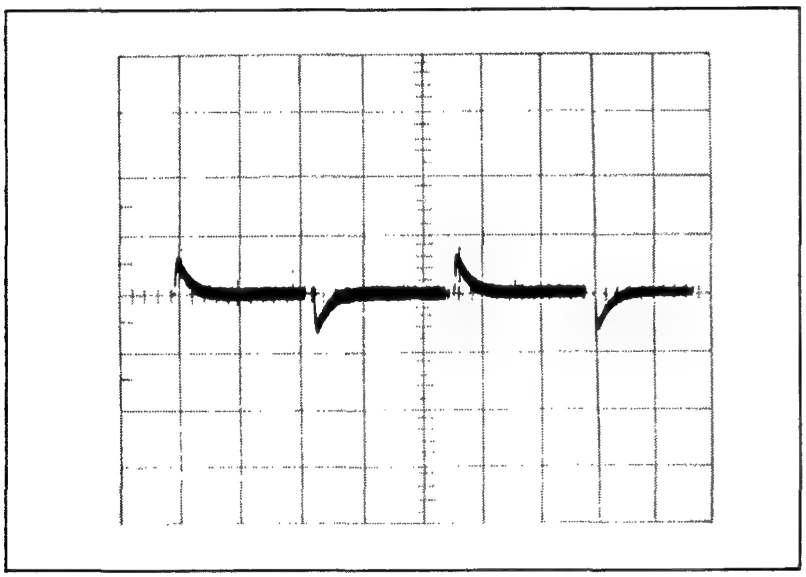


Figure 4-3b.
Undercompensated P/Z

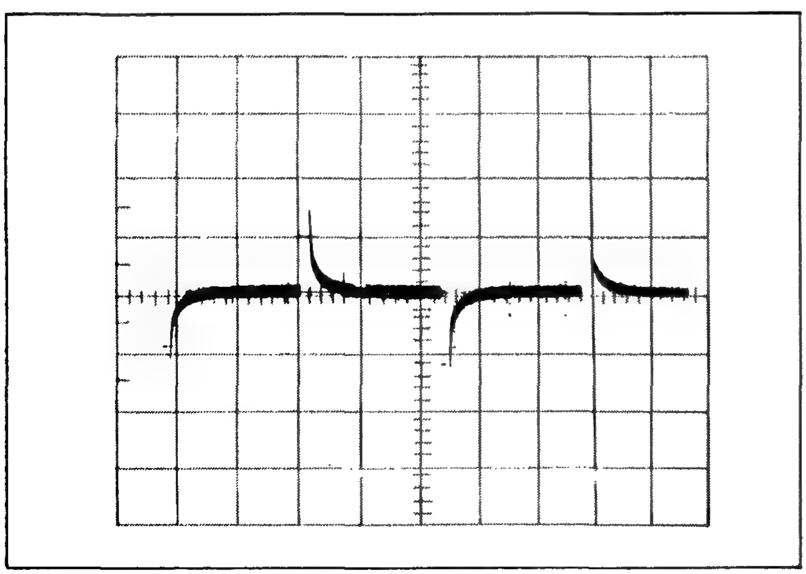


Figure 4-3c.
Overcompensated P/Z

Oscilloscope
Vert: 50mV/Div.
Horiz: 0.2μsec./Div.

Figure 4-3. Pole/Zero Adjustment using square wave pulse and preamp test input.

Section 5
CHECKOUT AND MAINTENANCE/CALIBRATION

5.1 GENERAL

The purpose of this section is to familiarize the user with the controls of the Model 2011 Spectroscopy Amplifier, so that the best performance can be obtained. The checkout will serve to verify that the module is in good operating order. The instructions which follow are primarily directed toward the Model 2011 only. Please refer to the Instruction Manuals of the other equipment used if questions or difficulties arise in their use.

5.2 INSTALLATION

The Canberra Model 2000 NIM Bin and Power Supply or other bin and power supply systems conforming with the mechanical and electrical standards set by AEC Report TID-20893 (Rev.) will accommodate the Model 2011. The right side cover of the two-width NIM module acts as a guide for insertion of the instrument. Secure the module in place by turning the two front panel captive screws clockwise until finger tight. It is recommended that the NIM bin power switch be OFF whenever the module is installed or removed.

The Model 2011 can be safely operated where the ambient air temperature is between 0°C and + 50°C (+120°F maximum). Perforations in the top and bottom sides permit cooling air to circulate through the module. When relay rack mounted along with other "heat generating" equipment, adequate clearance should be provided to allow for sufficient air flow through both the perforated top and bottom covers of the NIM Bin.

5.3. EQUIPMENT REQUIRED

a. Oscilloscope (Tektronix Models 453, 581, 465, or equivalent)

b. Digital Voltmeter ($<$ 0.1% Full Scale Accuracy)

c. Resistive Voltmeter Probe (200 to 1K ohms in series)

d. Current Meters (In-house equipment)

e. Noise Meter (Model HP-400H or equivalent)

f. Pulser - Model 1407 (either standard or modified for 20V Out)

g. NIM Power Supply

5.3.1 NIM VOLTAGE CHECK

With a DVM, measure the NIM Power Supply voltages and adjust if they are outside of the following ranges:

+24V:	+23.98 to +24.02V
- 24V:	- 23.98 to - 24.02V
+12V:	+11.99 to +12.01V
- 12V:	- 11.99 to - 12.01V

5.3.2 CURRENT MEASUREMENTS

a. Apply power to the 2011 and measure the currents. They should be within the following ranges:

+24V	65 to 85mA
+12V	25 to 45mA
- 12V	35 to 55mA
- 24V	70 to 90mA

NOTE: A greater deviation in currents indicates a faulty unit. Gross errors would probably be due to faulty or reversed capacitors, shorted or open transistors, etc.

b. Replace the current meters with a power cable.

5.4 DC LEVEL CHECKS AND ADJUSTMENTS

1. Initial Setup

a. Set the 2011 Controls as follows:

COARSE GAIN: 300

SHAPING: 4μsec

b. Connect a 93 ohm terminator to the 2011 rear panel Input.

5.5 AMPLIFIER DC LEVELS

1. Monitor TP1 with the DVM and adjust RV4 for - 50 to +50mV.

5.6 RESTORER THRESHOLD DC LEVELS

1. Measure the DC levels at the following points.

A3 pin 3:	- 400 to - 600
A3 pin 2:	0 to - 320mV

2. Measure the DC level at A2 pin 6 versus COARSE GAIN. The level should be within the range indicated below:

COARSE GAIN	A3 PIN 6
10, 30	- 140 to +15mV
100, 300	- 120 to +30mV
1K	- 100 to +60mV
3K	- 50 to +120mV

5.7 OUTPUT DC LEVELS

1. Monitor TP7 (UNIPOLAR OUTPUT) with a DVM and adjust RV3 for - 1 to + 1mVDC.

2. Measure the BIPOLAR OUTPUT DC Level. It should be - 20 to +20mV.

5.8 OUTPUT CHECKS

1. Equipment Setup

   a. Set the controls as follows:

   2011 Controls

COARSE GAIN	300
FINE GAIN	10
SHAPING	3μsec.
POLE ZERO	Fully CCW
INPUT POLARITY	POS
UNIPOLAR ZOUT JUMPER PLUG (J8)	93 ohms
BIPOLAR ZOUT JUMPER PLUG (J9)	93 ohms

   1407 Controls

PULSE HEIGHT:	7.0 (3.5 if modified 1407)
NORMALIZE:	10
POS/NEG:	POS
60HZ/OFF/90HZ:	90HZ
RISE TIME:	MIN
FALL TIME:	400μsec.
ATTENUATION:	X100

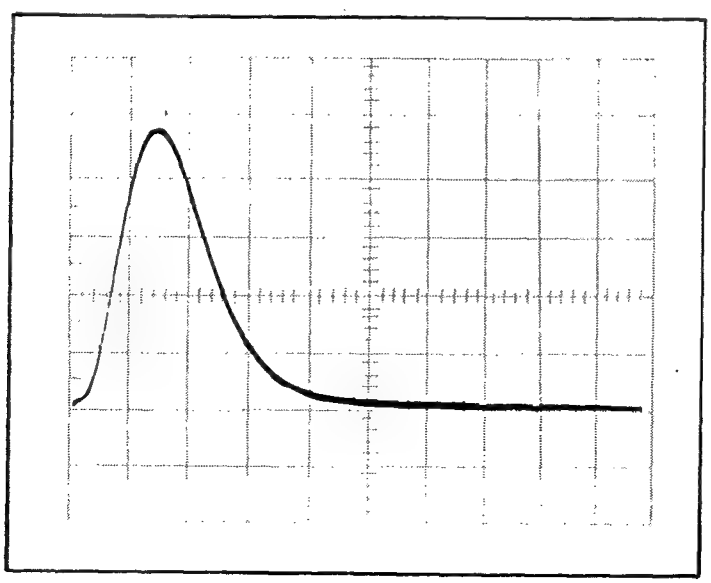
2. Connect a 93 ohm terminator to the 2011 Rear Panel Input.

3. Connect the 1407 ATTEN OUTPUT to the 2011 Front Panel Input with RG-62 coax cable.

4. Connect the 1407 NORM OUTPUT to the scope Ext TRIG Input with RG-62 coax cable. Set the scope triggering to EXT, +.

5. Unipolar Output

   a. Connect the UNIPOLAR OUTPUT to the scope with RG-62 coax cable, using a "T" connector at the scope. You should observe the Gaussian shaped pulse shown in Figure 5.1.



Amplitude
9 to 11

Figure 5.1 UNIPOLAR OUTPUT (2V, 5μsec./div.)

b. Adjust the 1407 PULSE HEIGHT until the Unipolar Output amplitude is +9.9 to 10.1V.

c. Observe the peak of the Unipolar pulse and place the 2011 Delay Jumper Plugs J6 and J7 in their IN positions. The peak of the Unipolar pulse should now be delayed by 1.7 to 2.3μsec. The amplitude of the pulse should be 9.0 to 11.0V. There should be no discernible distortion to the pulse shape.

d. Return J6 and J7 to their OUT positions.

e. Connect a 93 ohm terminator to the "T" connector at the scope input. The amplitude of the Unipolar pulse should be +4.8 to 5.2V. Remove the 93 ohm terminator.

f. Place the UNIPOLAR ZOUT jumper plug J8 in the 0 ohm position. The amplitude of the Unipolar Pulse should be +9.9 to +10.1 volts.

g. Connect the 93 ohm terminator; the amplitude should not decrease by more than 100mV. There should be no discernible distortion in the pulse shape. Remove the terminator.

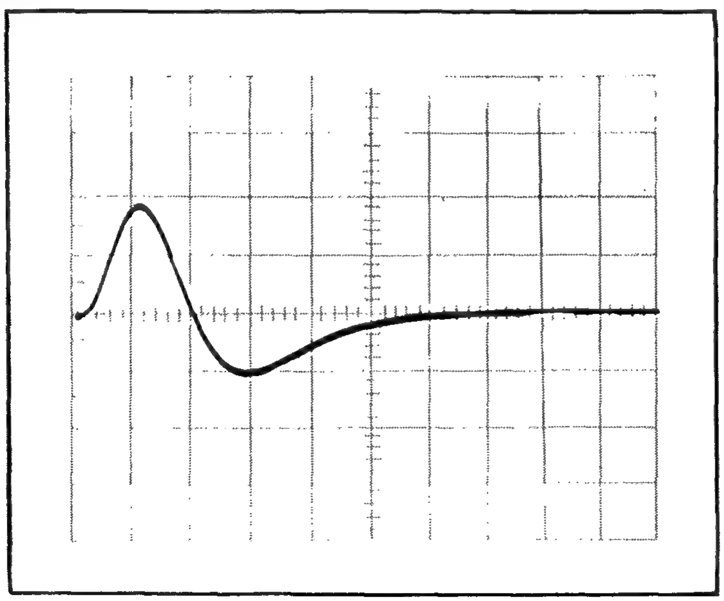
h. Set the 1407 ATTENUATION to X10. The Unipolar Pulse should be clamped at +12.0 to +13.5 volts.

i. Set the 1407 ATTENUATION to X100.

j. Connect the cable to the rear panel UNIPOLAR OUTPUT BNC. Connect the 93 ohm terminator. The Unipolar Pulse amplitude should be +4.8 to +5.2 volts. Remove the 93 ohm terminator.

5.8.6 BIPOLAR OUTPUT

a. Connect the cable to the front panel BIPOLAR OUTPUT. You should observe the bipolar pulse shown in Figure 5.2.



Amplitude + 8.5 to + 11.5V
- 4 to - 6V

Figure 5.2. BIPOLAR OUTPUT (5V, 5μsec/div.)

b. Adjust the 1407 PULSE HEIGHT until the positive amplitude of the Bipolar Pulse is +9.9 to 10.1V.

c. Connect the 93 ohm terminator to the "T" connector. The positive amplitude of the Bipolar Pulse should be +4.8 to +5.2V. Remove the 93 ohm terminator.

d. Place the BIPOLAR ZOUT J9 jumper plug in the 0 ohm position. The positive amplitude should be +9.9 to +10.1 volts.

e. Connect the 93 ohm terminator; the amplitude of either the positive or negative portions of the Bipolar Pulse should not decrease by more than 100mV. There should not be any discernible distortion to the pulse shape. Remove the terminator.

f. Set the 1407 ATTENUATION to X10. The Bipolar pulse should be clamped at +12.0 to +13.5V.

g. Set the 1407 ATTENUATION to X100.

h. Connect the cable to the Rear Panel BIPOLAR OUTPUT. Connect the 93 ohm terminator. The positive amplitude of the Bipolar pulse should be +4.8 to +5.2V. Remove the terminator.

5.9 POLE ZERO ADJUSTMENT

1. Set the 1407 FALL TIME to 50μsec.

2. Observe the UNIPOLAR OUTPUT on the scope and adjust the P/Z control so that the tail of the Gaussian pulse returns to the baseline as fast as possible with NO under or overshoot, as in Figure 5.3.

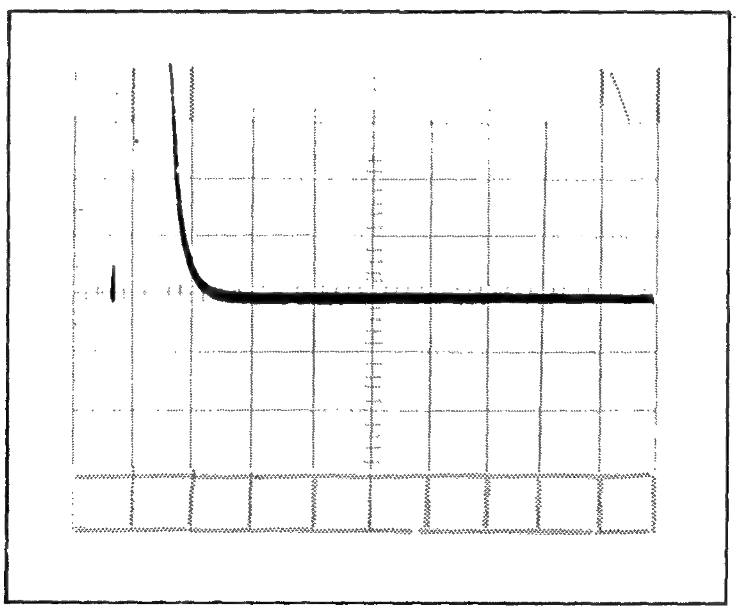


Figure 5.3. Pole Zero Adjustment, UNIPOLAR OUTPUT (0.1V, 20μs/div.)

5.10 COARSE AND FINE GAIN CONTROLS

1. Set the 2011 COARSE GAIN to 3K.

2. Connect the UNIPOLAR OUTPUT to the scope with RG-62 coax cable.

3. Set the 1407 ATTENUATION to X1000. Adjust the 1407 PULSE HEIGHT until the Unipolar Output pulse attains an amplitude of +9.9 to +10.1V.

4. Measure the Unipolar Output amplitude for each COARSE GAIN setting. The amplitudes should be within the range indicated in Table 5.1.

COARSE GAIN	UNIPOLAR OUTPUT AMPLITUDE	
3K	9.9 to 10.1	V
1K	3.0 to 3.6	V
300	0.9 to 1.1	V
100	280 to 360	mV
30	80 to 120	mV
10	28 to 36	mV

Table 5.1. Unipolar Output Amplitude Versus Coarse Gain

5. Set the 2011 COARSE GAIN to 3K.

6. Monitor the Unipolar Output on the scope and turn the 2011 FINE GAIN Control to minimum. The amplitude of the Unipolar Output pulse should decrease to +2.7 to +3.3V.

7. Return the FINE GAIN to maximum and the COARSE GAIN to 300. Set the 1407 ATTENUATION to X100. Set the FINE GAIN to maximum.

5.11 SHAPING CHECKS

1. Put side covers on the 2011.

2. Observe both the Unipolar and Bipolar Outputs on the scope. Measure the amplitudes of the Outputs at all positions of the 2011 SHAPING switch. The amplitudes should be within the following ranges:

Unipolar Amplitudes:	+9.0 to +11.0V
Bipolar Amplitudes:	+8.0 to +12.0V

5.12 NOISE MEASUREMENTS

1. With side covers on the 2011.

2. Set the 2011 Controls as follows:

COARSE GAIN:	100
SHAPING:	3μsec.

3. Connect a "T" connector to the 2011 INPUT. Connect the 1407 ATTEN OUTPUT cable to the "T" connector. Connect a cable from the other end of "T" connector to the scope Input. You will observe a positive tail pulse on the scope. Set the 1407 ATTENUATION to X10 and adjust the PULSE HEIGHT until the tail pulse attains an amplitude of 100mV.

4. Monitor the UNIPOLAR OUTPUT on the scope and adjust the 2011 FINE GAIN until the Unipolar Output amplitude is 10V.

5. Remove the "T" connector and cables from the 2011 INPUT. Leave the 93 ohm terminator on the Rear Panel Input. Set the 1407 60 Hz/OFF/90 Hz switch to OFF. Connect the UNIPOLAR OUTPUT to the Noise Meter with RG-62 coax cable and measure the noise. It should be less than 0.31mV for an averaging meter and 0.35mV for a true RMS Voltmeter.

6. Measure the BIPOLAR OUTPUT Noise. It should be less than 0.58mV for an averaging meter and 0.66mV for a true RMS Voltmeter.

5.13 LINEARITY CHECK

One of the simplest and most accurate tests is to set up the system shown in Figure 5.4.

This test is performed by adjusting the pulser attentuator and amplifier gain so that with a ten volt high level (direct) output from the pulser, the output from the amplifier is also exactly ten volts. This may be ascertained by adjusting the pulser attenuator and amplifier gain so that the null point observed on the oscilloscope is at exactly the same level as the baseline with the highest oscilloscope vertical gain.

When this condition is obtained, turn the pulser height control downward from ten volts to the lowest level that will still trigger the oscilloscope, and observe the maximum difference between the baseline and the null point. The integral linearity of the amplifier under test is then equal to:

$$\frac{(\text{Maximum deviation in volts}) \times 2 \times 100\%}{10 \text{ Volts}}$$

The maximum deviation must thus be less than ± 2.5mV in order to meet the ± 0.05% specification.

The test may be explained as follows: Integral nonlinearity is the maximum deviation from the straight line plotted on an output vs. input plot from zero output to rated output (10 volts) divided by the rated output stated as a percentage.

This calculation is performed electronically by the test described above by setting:

$$\text{OUTPUT} = \text{K} \times \text{INPUT}$$

Where K is the pulser attenuation factor and the gain of the amplifier. As the input is decreased, the amplifier gain should remain constant (output should decrease linearly); whether or not it does is tested by comparing the output to a signal known to decrease linearly with the amplifier input; the pulser's direct output meets this requirement since it is related to the amplifier input by a passive attenuator. The factor of two must be included because the summing network also serves as a voltage divider decreasing the apparent deviation by a factor of two.

Note that nonlinearity and instability in the pulser output do not enter into the question, because both direct and attenuated outputs will be affected identically, save for the negligible effect of the pulser's attenuator instabilities over the short time period required for the test. Instabilities in the baseline level on the oscilloscope are due to oscilloscope triggering and DC level fluctuations and need not be of concern in this test.

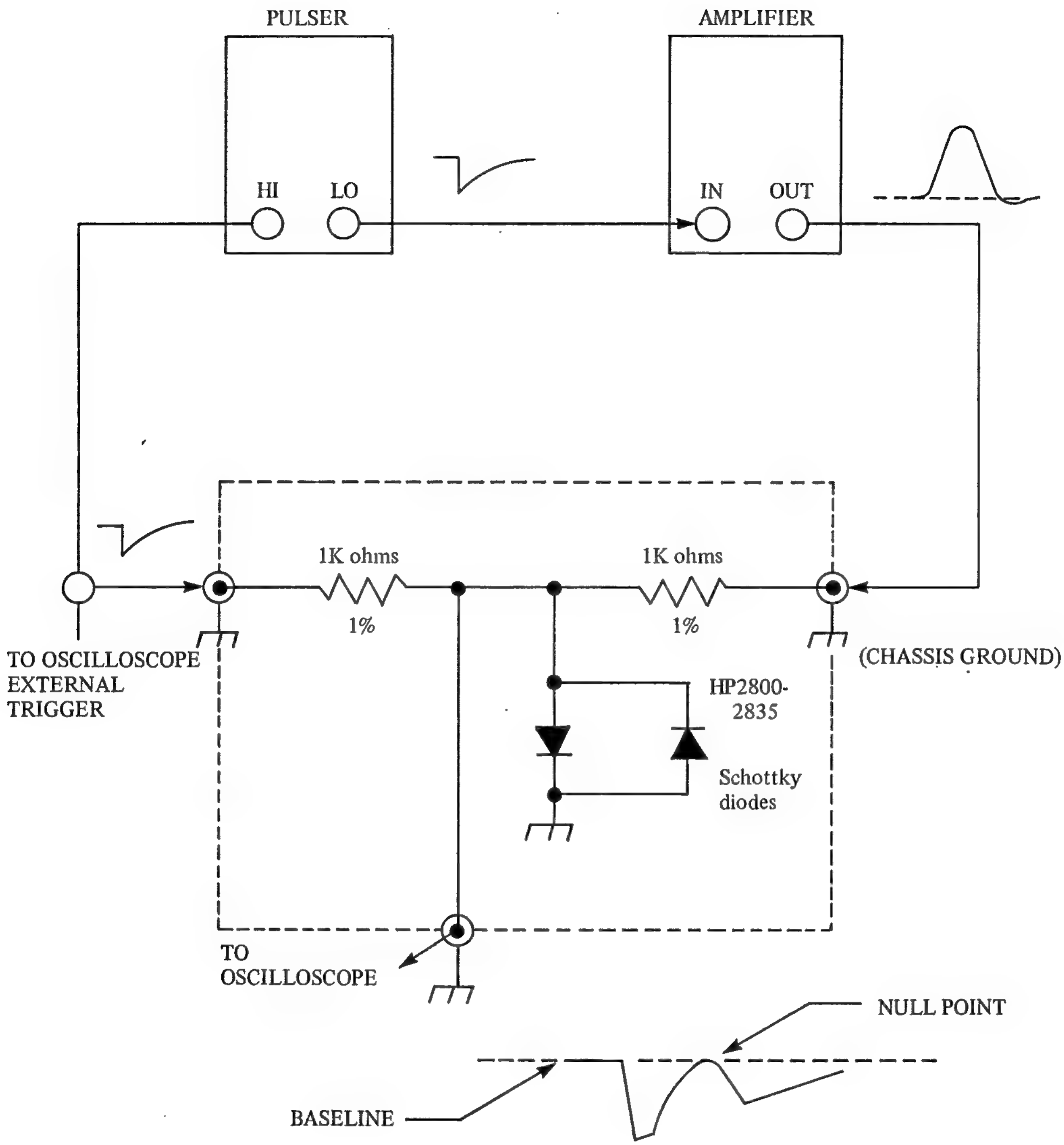


Figure 5.4. Test Setup; Linearity Check

Section 6
THEORY OF OPERATION

6.1 GENERAL

This section of the manual contains a description of the circuitry used in the Model 2011 Spectroscopy Amplifier. Components are referred to be reference designations such as Q2, C5, and R10. Throughout the following circuit analysis, refer to the circuit schematics located in the drawings section.

6.2 BLOCK DIAGRAM DESCRIPTION

The preamp signal enters either the front panel Input BNC (J1) or the rear panel Input BNC (J101) where the signal is first differentiated by C11, C12 and C13 (depending on the shaping time constants selected by S3A and S4B) and R20. The signal is also pole zeroed by resistors R22, R23 and R24 (depending on the shaping time constants selected by S3C and S4D) and RV2. The setting of the COARSE GAIN switch determines if the signal is next amplified by K1, K2 and K3 or just by K1 and K3. The amplified signal is next integrated by the first complex pole integrator, A6. The integrated signal goes to the Polarity Amplifier, A5. Amplifier A5 is non-inverting depending on the switch position of S2. The output of the Polarity Amplifier, A5, is connected through the bipolar differention Network C51, C52 and C53 (the differention capacitors are selected by the shaping switch S3N and S4N) and R81 then connected to the Bipolar Output Amplifier and driver. The bipolar signal is connected to the front and rear panel BNC connectors J5 and J103 respectively. The output of the Polarity Amplifier is also connected to the combination Unipolar Output amplifier/Output Driver and DC Restorer through the delay line network consisting of jumper plugs J6 and J7, resistors R94, R95, R96, RT1 and R100 and delay line DL1. The unipolar signal is connected to the front and rear BNC connectors J3 and J102.

6.3 DETAILED CIRCUIT DESCRIPTION

6.3.1 GAIN AMPLIFIERS

All gain (K1, K2, & K3) is accomplished before the integration occurs. Only amplifiers K1 & K3 are used at low gains to avoid excessive attenuation between gain stages. As a result, the input amplifier K1 is always the dominant noise source, K2 is added to the circuit at high gains. This enables each of the three gain stages to operate at relatively low closed loop gains to prevent gain shift with temperature.

Amplifiers K1 (Q1 through Q6), K2 (Q7 through Q12), and K3 (Q13 through Q18) are all basically the same configuration; therefore, only K1 will be fully described.

The differential input pair Q1 drives the common base transistors Q2 and Q3. Transistors Q2 and Q3 are operated at low current levels, providing a high output impedance to drive the output transistors Q5 and Q6, through the common source FET Q4. The necessary current to drive the FET and circuit capacitors at high frequencies is derived directly from the input transistor Q1, through the low impedance of Q2 and Q3. This gives a slew rate for the amplifier of 140 volts per microsecond. C4 provides feedback for closed loop stability, and allows the amplifier to follow a 100 nanosecond rise time signal without losing feedback control. Since the gain amplifiers do not require DC stability and are operated as inverting amplifiers, a constant current source is not needed in the emitters of Q1. Transistors Q5 and Q6 are biased on by R8 and R16, with the junction of R10 and R17 providing the low impedance output.

6.3.2 INPUT AMPLIFIER K1

The first differentiation network and Pole/Zero cancellation circuitry are both located at the inverting input of K1. The SHAPING switch (sections S3A and S4B) selects the passive differentiator capacitors C11 through C13 and switch, sections S4D and S3C, selects the P/Z compensating resistors R22 through R24, for the selected time constant. POLE/ZERO Control RV2 sets the degree of P/Z compensation. DC Balance control RV4 is factory set so that changes of the FINE GAIN Control RV1 will not shift the Output DC level of K1. D1 is a fast switching protection diode for overload signals.

6.6.3 GAIN AMPLIFIERS K2 & K3

Amplifier K2 is non inverting with a gain of 30 determined by R39 and R40. It is switched into the circuit by the COARSE GAIN switch S1 only for gains above 300. Diode D2 prevents a charge from accumulating on C20 under overload conditions.

K3 is an inverting amplifier with its gain controlled by the ratio of the parallel combination of R60 and R67, and input resistors R56 through R58, selected by the COARSE GAIN switch. Diodes D5 and D6 provide overload protection. Capacitor C42 makes the gain stage AC coupled with a time constant of C42 and R67. This very long time constant contributes to the effectiveness of the DC restorer.

6.3.4 INTEGRATOR AMPLIFIER A6

Active integrator A6 provides complex pole pairs which have the Locus of the poles equidistant from the origin. The real part of the complex poles are equal to the pole in the last integrator (Output Amplifier A1). The real pole of the differentiator is 1.6 times this value. Active filter networks for A6 are selected by the SHAPING switch S3J, S3L, S4J and S4M for the desired time constant.

Amplifier A6 is a wide band, high slew rate, integrated circuit operational amplifier. It is connected in a non-inverting configuration with a DC gain of 1.

6.3.5 POLARITY AMPLIFIER

The integrated signal is used to drive the polarity amplifier A5. Amplifier A5 is a wide band, high slew rate, integrated circuit operational amplifier. When the Input polarity switch is set negative (-) the gates of FETS Q19 and Q32 are driven to approximately - 17 volts, turning them off. Since pin 3 of A5 is not tied to ground and allowed to follow the signal at TP4, the amplifier acts as a voltage follower with unity gain. When the Input polarity switch is set positive (+), both FETS Q19 and Q32 turn ON shorting pin 3 of A5 to ground. With A5 pin 3 grounded the amplifier has an inverting gain of 1.

6.3.6 UNIPOLAR OUTPUT, INTEGRATOR AND DRIVER

DL1 can delay the integrated signal of the polarity amp A5 by approximately 2 microseconds when switched into the circuit by the DELAY jumper plugs J6 and J7. The delay line is temperature compensated for signal gain changes by the Varistor RT1.

The unipolar output amplifier is comprised of A1 and a power output driver, Q29, Q30 and Q31. Integrated circuit A1 is a wide band, high slew rate operational amplifier. The overall amplifier (op-amp and driver) provides an inverting gain of 2 with single pole integration (C63 through C65) to minimize noise introduced after the Polarity amplifier A5.

The output driver transistors are running Class “AB”. Diodes, D15, D18 and current source Q31 form the biasing network for the output transistors.

Diodes D16 and D17 provide short circuit protection. When a short circuit is connected to the output and the voltage drop across R110 or R111 equals or tries to exceed the diode drops of D16 or D17 the output current will be limited to approximately ± 200mA. Diodes D13 and D14 provide limiting so that the output transistors do not go into saturation, preventing base-emitter charge storage.

Two UNIPOLAR OUTPUTS are provided. The front panel output provides both a low impedance 1 ohm and a 93 ohm, internally selectable by J8. The low output impedance can drive up to 10 feet of 93 ohm coax cable whereas the 93 ohm output can drive hundreds of feet of 93 ohm coax cable. The rear panel output has a fixed 93 ohm series-connected output impedance.

6.3.7 RESTORER

The restorer circuitry consists of the output amplifier A1, transistor array A2, dual differential comparator A3 and transistors Q24 through Q28 and Q23. The restorer is a transconductance type amplifier; it develops a constant current of the polarity at its output (junction of Q24 collector and A2 pin 15, this generates a voltage on C75 which is buffered by FET Q23 and summed in at A1 pin 3, forcing the output of the AMP OUTPUT (TP7) to 0 volts, maintaining the baseline. When A3 detects a signal, its output causes Q27 to turn off. Q26 switches on a current sufficient to back bias current source 1a of A3 which disables the restorer. Capacitor C81 AC couples to transistor Q27 preventing any restorer latch up problems. The UNIPOLAR OUTPUT signal (TP7) is clamped by diode network D23 and D24 and connected to the comparator input A3 pins 5 and 2.

The negative restorer gate threshold is set at - 500MV by resistors R143 and R144. The positive threshold is variable and dependent on the setting of the coarse gain switch S16 and resistors R138 through R140 and R145 through R147. Pot RV3 adjusts the offset of the restorer output and the Unipolar Output (TP7) to ground.

6.3.8 BIPOLAR OUTPUT AND DRIVER

The Bipolar Output Amplifier, A4 and transistors Q20, Q21 and Q22, recovers the gain lost by the integrator stage and second differentiator (C51 through C53). The Bipolar Output is short circuit protected, can drive up to ± 10 volts at ± 200mA. The Bipolar Output Amplifier circuitry is identical to that used in the Unipolar Output Amplifier, and it provides the same type of output flexibility. The Bipolar Amplifier has some integration (C54 through C56) which integrates out the signal bleed-through from the first complex integrator.

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